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Observations on *Scutellista cyanea* Motsch. (Hymenoptera: Pteromalidae)

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Abstract.—*Scutellista cyanea* Motsch. is a facultative parasite/predator of black scale (*Saissetia oleae* (Olivier)) which is relatively common on olive in northern California. An analysis involving >50 trees and at three spatial scales revealed that percent of ovisac-stage scales attacked by *S. cyanea* in relation to scale density was either density independent (among twigs within a tree) or inversely density dependent (among trees averaged by site, all trees regardless of site). The overall rate of attack was relatively low in each case. As a consequence, *S. cyanea* probably had a limited impact on the scale populations under investigation. The ability of *Scutellista* to satisfactorily control its host is also limited by factors intrinsic to the natural enemy itself.

Black scale, *Saissetia oleae* (Olivier), is a polyphagous, cosmopolitan soft scale which was introduced into California over 100 years ago. It first became a target for classical biological control ca. 1890, and over the years, ca. 50 species of exotic predators and parasites have been introduced and released in the state (Smith and Compere, 1928; Flanders, 1965; Bennett et al., 1976; Bartlett, 1978). As a result, several species are established and provide substantial to complete levels of biological control of black scale on both citrus and olive. Of these exotic natural enemies, one of the most conspicuous is *Scutellista cyanea* Motsch. (Hymenoptera: Pteromalidae). It is a rather unusual natural enemy because it can develop either as a parasite (=parasitoid) or a predator. The female inserts the egg through the posterior arch of the third-instar female scale, and if no host eggs have been deposited, the *Scutellista* larva can develop as an ectoparasite of the scale. If the scale has deposited eggs, the larva develops as an "egg predator." During the recent eradication campaign directed against Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), Ehler and Endicott (1984) assessed the effects of malathion-bait sprays on the biological control of various insect pests, including black scale on olive. *Scutellista* was one of the more common natural enemies of black scale in the study zone, and as a consequence, a considerable amount of data relative to its ecological impact was obtained. The purpose of the present paper is to assess these data, with particular reference to spatial variation in attack rates.

MATERIALS AND METHODS

Ehler and Endicott (1984) sampled 108 olive trees in western Stanislaus County on three dates in 1982 and one date in 1983. Fifty-four trees were sampled in both the medfly spray zone and the adjacent unsprayed area; trees in the former were distributed among 13 sites, compared to 15 sites for the latter. There is

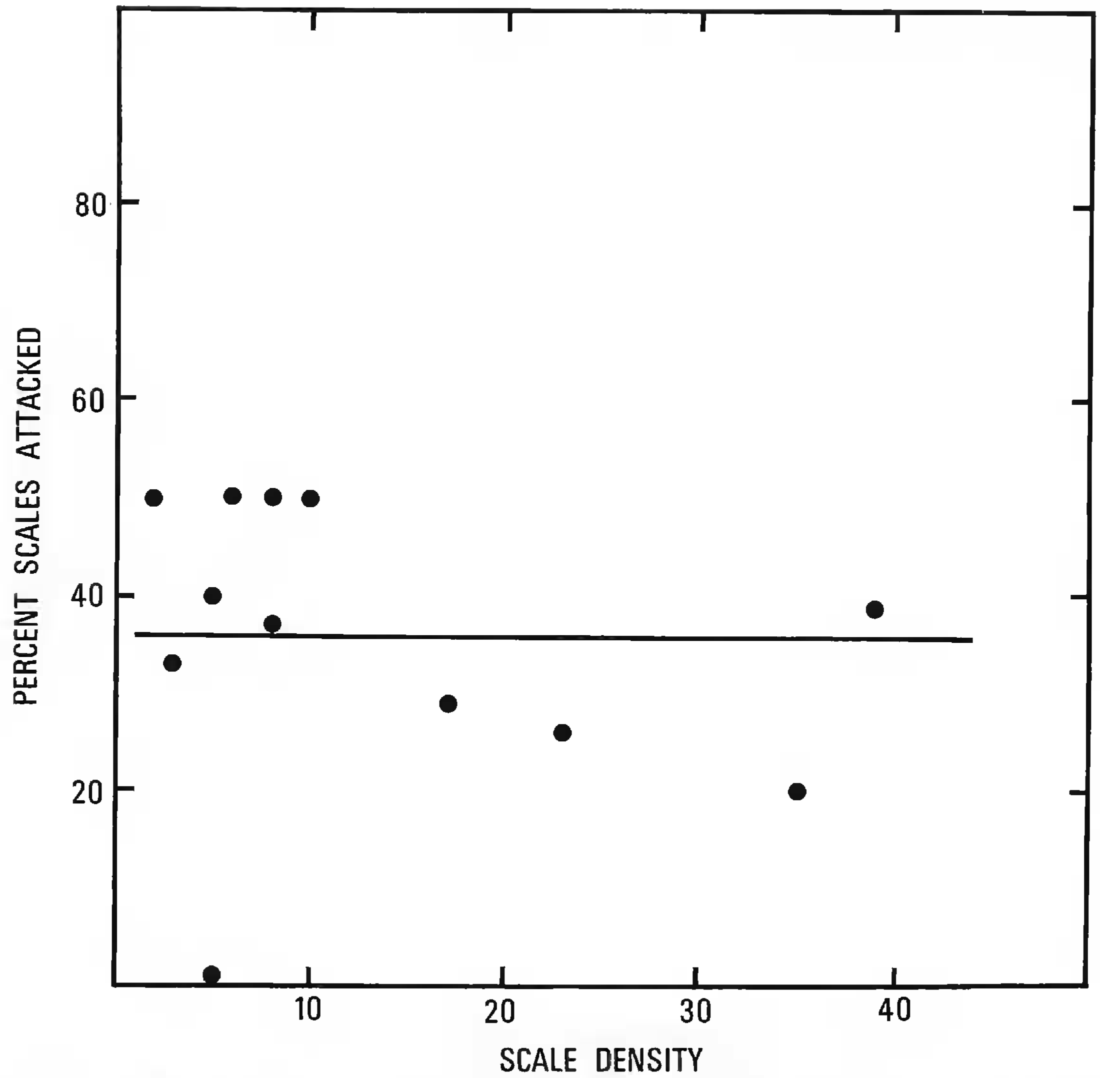

Figure 1. Relationship between (1) percent of ovisac-stage black scales attacked by *Scutellista* and (2) number of ovisac-stage scales per twig on tree no. 73 (9–10 Aug. 1982). Regression/correlation statistics as follows: $Y = 39.26 + (-0.29X)$, $r^2 = 0.06$, $P = 0.23$. Line represents grand mean (35.4) rather than calculated regression line.

essentially no commercial olive production in the region and therefore the study was restricted to dooryard and roadside trees. Actually, this was advantageous because the trees chosen were not subject to chemical insecticides—neither in recent years nor during the course of the investigations. On each sample date 24 twigs were removed from around the skirt of the tree, placed in a plastic bag, transferred to the laboratory, and stored at 10°C. At a later date twigs were examined with the aid of a dissecting scope in order to determine scale density and parasitization/predation.

With respect to *Scutellista,* the proportion of scales attacked in relation to scale density was assessed for three spatial scales. These were as follows: (1) individual twigs from the same tree; (2) individual trees, averaged by site; and (3) individual trees, without regard to site. Female black scales develop through three instars; the third instar is generally divided into the nongravid, gravid and ovisac stages. *Scutellista* characteristically exploits the ovisac stage, and in the present paper, its ecological impact is expressed in terms of the proportion of ovisac-stage black scale attacked in relation to the number of these scales per unit. The present analysis is based on data from the 54 trees in the unsprayed area during 1982 (sample dates: 8–10 Mar., 25–26 May, 9–10 Aug.) and from all 108 trees in 1983 (sample date: 30 Mar.). The trees from the spray zone were included in the latter case because the last malathion-bait spray was applied on 13 March of the pre-

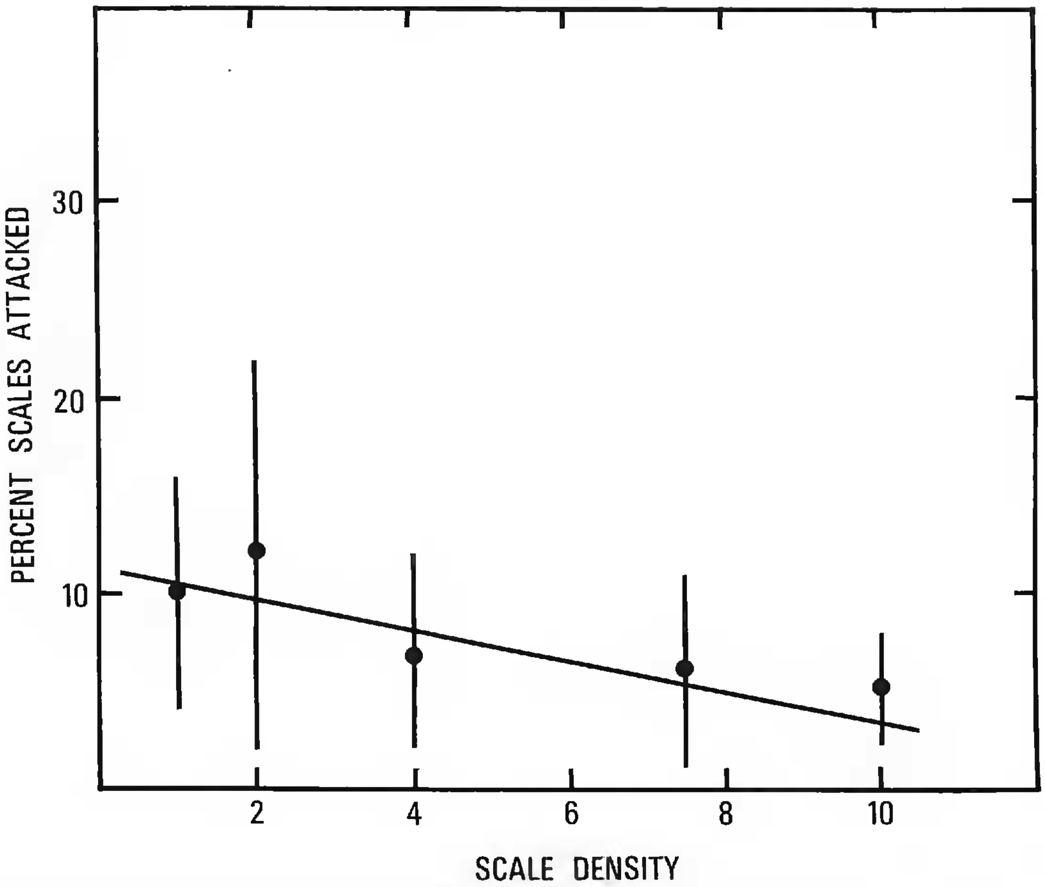

Figure 2. Relationship between (1) average (±SEM) percent of ovisac-stage black scales attacked by *Scutellista* and (2) average number of ovisac-stage scales per 24 twigs per tree per site. Regression/correlation statistics as follows: $Y = 11.07 + (-0.65X)$, $r^2 = 0.71$, $P = 0.04$. Last three points represent average for sites with 3–5, 7–8, and ≥10 scales per 24 twigs. Sample sizes for points left to right = 19, 8, 7, 5, and 8.

ceding year. One tree yielded a sufficient number of twigs infested with ovisac-stage scales to permit an analysis of spatial density dependence among twigs on the same tree. For the remaining two spatial scales, it was necessary to pool data from all sites and sample dates, so that the resulting relationships contain both spatial and temporal elements.

Results and Discussion

The relationships between scale density and proportion attacked by *Scutellista* for the three spatial scales are shown in Figures 1–3. For tree no. 73 on 9–10 August 1982, proportion attacked was independent of density per twig (Fig. 1). This is a proper measure of spatial density dependence, and the lack of a direct response is consistent with the hypothesis that *Scutellista* does not aggregate in areas (twigs) of high host density within the tree. However, this hypothesis requires further testing. With respect to sites, the proportion attacked was inversely density dependent—i.e., average proportion attacked (per tree) at a given site was inversely related to average density (Fig. 2). The data in Figure 2 are grouped into five categories along the X-axis and the regression is based on mean values for these groups. A regression based on all points ($n = 47$) revealed a density-independent relationship [$Y = 10.97 + (-0.66X)$, $r^2 = 0.01$, $P = 0.23$]. The proportion of scales attacked per tree—regardless of site—was also inversely density dependent (Fig. 3). The latter two analyses are spatial/temporal in scope and are not (in the strict sense) relevant to the current debate over the incidence and importance of spatial density dependence. However, these analyses do give a regional view of

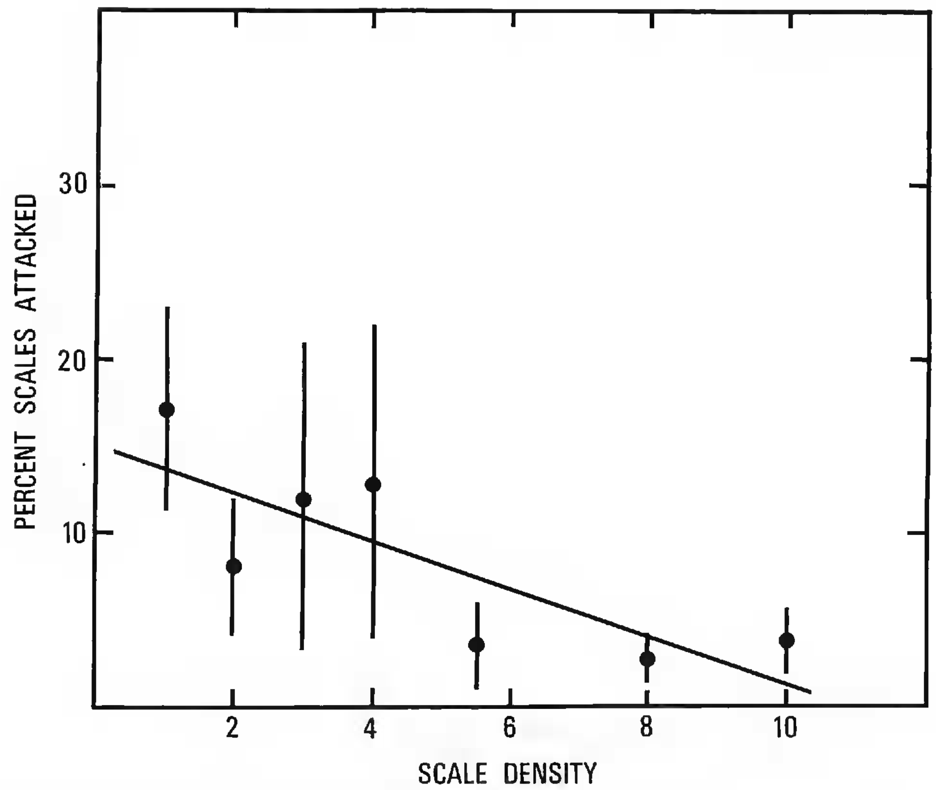

Figure 3. Relationship between (1) average (±SEM) percent of ovisac-stage black scales attacked by *Scutellista* and (2) number of ovisac-stage scales per 12 twigs per tree, regardless of site. Regression/correlation statistics as follows: $Y = 14.93 + (-1.36X)$, $r^2 = 0.67$, $P = 0.01$. Last three points represent average for trees containing 5–6, 7–9, and ≥10 scales per 12 twigs. Sample sizes for points left to right = 42, 27, 10, 10, 10, 9, and 13.

the host-enemy interaction. Nevertheless, the relatively low rates of attack, and the lack of direct density-dependent responses, clearly indicate that *Scutellista* had a limited impact on black scale populations in the study area.

The ability of *Scutellista* to satisfactorily control black scale is also limited by factors which are intrinsic to the natural enemy itself. It is well established that the *Scutellista* larva does not necessarily eat all of the host eggs available to it. As the number of eggs deposited is a function of scale size, the predation rate also varies with host size. For example, Quayle (1911) noted that virtually all of the eggs associated with relatively small scales (≤500 eggs/female) were consumed by a single *Scutellista,* whereas many remained (and eventually hatched) after a larva completed development in a larger host (>2000 eggs/female). Mendel et al. (1984) provided more precise estimates of predation rates. They found that during the winter, female scales were relatively small (<400 eggs/female) and a single *Scutellista* would destroy up to 90% of the eggs. In contrast, scales during the spring were much larger (700–1200 eggs/female) and a single *Scutellista* would only consume up to 50% of the eggs. Such a situation would be compounded when a *Scutellista* female oviposited under a female scale after the scale's eggs had begun to hatch. Thus, even relatively high rates of attack by *Scutellista* may very well have a limited effect on the scale population. In this context, Ehler (1978) compared the number of first- and second-instar scales on isolated olive twigs containing one mummified female scale and found that progeny per twig for scales attacked by *Scutellista* was ca. one-third that observed for non-attacked or non-parasitized scales. In the present case, analysis of data from 9 to 10 August 1982 revealed a similar trend—i.e., an average of 18.7 immature scales on twigs containing a single female (n = 26) compared to 7.13 immature scales on twigs containing a single female from which a *Scutellista* had emerged ($n = 8$). However, this difference was not significant ($t = 1.37$, $P = 0.09$).

In future biological-control programs, some attention should perhaps be given to natural enemies whose efficiency is limited by "intrinsic" factors. Whether or not to introduce these natural enemies should probably be assessed on a case-by-case basis. For example, a species such as *Scutellista* could pose a special problem if it attacked a relatively high proportion of the hosts (but had little ecological impact) and subsequently precluded the establishment of additional, more valuable species (i.e., competitive exclusion). The possibility of competitive suppression of more effective, established species by an intrinsically limited species should also be considered. In the case of black scale in California, the role of *Scutellista* in competitive exclusion of introduced species and in competitive suppression of established ones is not clear; some future research on this matter would seem warranted.

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